Defining Cryostat Penetrations

(Approaching from Calibration Task Force
&
Cryogenic Instrumentation and Slow Controls Consortium)

Sowjanya Gollapinni
Kendall Mahn

DUNE Technical Board meeting
August 31, 2017

Defining Cryostat Penetrations

- Defining cryostat penetrations ties to a bigger problem since one needs to understand the needed calibration systems for DUNE and to some level the instrumentation of devices so accommodations can be made in terms of
  - Numbers of feedthroughs
  - Location/Distribution of feedthroughs
  - Width of each feedthrough

Note: at this point we are only defining interfaces not the design of the actual systems

- Calibration Task Force and Cryogenic Instrumentation & Slow Controls Consortium working closely
  - I have been holding one-on-one meeting with my consortium members to motivate them to start thinking about this
  - Kendall and I have been taking input from key stakeholders and holding focused meetings to develop specific questions/studies we would need to address this problem

Challenge: Timeline

- Per Jim,
  - Need to finalize by first week on November
  - i.e., converge by end of October
- Per Eric,
  - Need to converge by first week of October (for the EC to review?)
  - Two TB meetings in September to discuss this
- Seems like we roughly have 3 to 4 weeks to converge on this!

Possible systems to consider

- Calibration and cryostat instrumentation systems need to be considered to make accommodations with the cryostat penetration design:
  - Thermometry
  - Purity monitors
  - Radioactive source calibration
  - Photon gain monitoring
  - Cameras
  - Laser system
- Keep the no. of penetrations as minimal as possible to reduce heat loads and leaks, but at the same time we want to make sure we can calibrate our detector!
  - Possible scenario: one feedthrough shared b/n multiple systems (e.g. radioactive source & thermometers, or thermometers & PMs)

Possible systems to consider

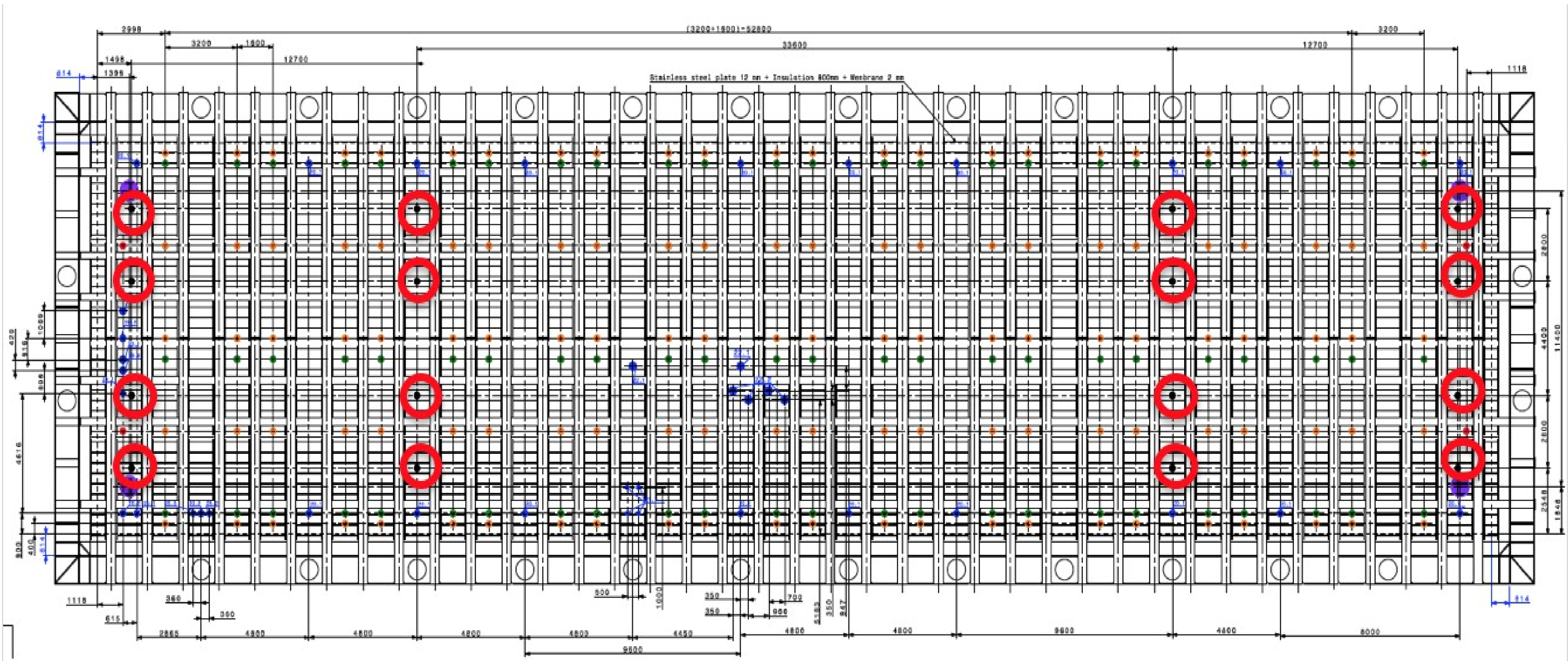
- Calibration and cryostat instrumentation systems need to be considered to make accommodations with the cryostat penetration design:
  - Thermometry
  - Purity monitors
  - Radioactive source calibration
  - Photon gain monitoring
  - Cameras
  - Laser system
- Keep the no. of penetrations as mi… loads and leaks, but at the same ti… calibrate our detector!
  - Possible scenario: one feedthrough shared b/n multiple systems (e.g. radioactive source & thermometers, or thermometers & PMs)

Do we need all these systems?

From the physics point of view, these systems are well motivated. (unprecedented physics requirements, so think redundant)

Each system comes with its own challenges and risks, which need to be addressed and mitigated through valid arguments/studies. That is the goal.

Current design for cryostat penetrations
(only showing the instrumentation ports)



Pos.	Diameter [mm]	Quantity	Description
1	Ø250	120	Support
2	Ø250	72	Cable
3	Ø250	4	High voltage
4	Ø250	16	Instrumentation
5	Ø800	4	Manholes

- 16 instrumentation ports
- 250 mm diameter (current design)

- About 0.5 m clearance on the sides
- About 0.7 m clearance on top from the surface of liquid argon

Current systems and requirements

- **Thermometers:** Monitor the detector during cool down; provide information on fluid and gas flow
  - Fixed thermometers vs Dynamic-vertical T-Gradient thermometers for cross calibration. Latter (favored) puts requirements on penetration width
  - Can only go on the ends of the cryostat.
  - How many thermometers? – not clear. Number required to model the fluid flow is not studied
- **Cameras (steerable?):** Not clear where it lives (HV? APA?)
  - Consider this as one system that can be deployed using an instrumentation port. Purpose/requirements need to be defined.
- **Purity Monitors**: Great during commissioning, initial data runs and low purity times
  - No. of purity monitors, requirements on FT width – not studied
  - Can protoDUNE design be extrapolated to DUNE? Not clear.

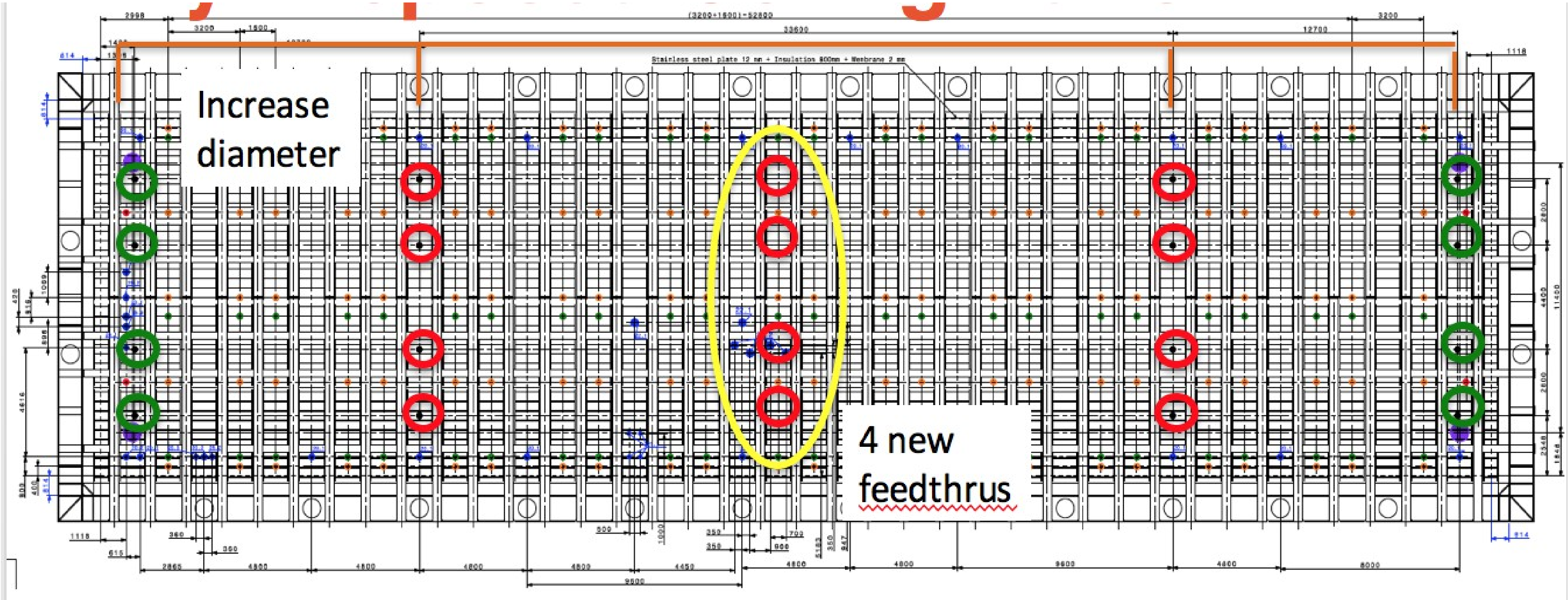
Current systems and requirements

- **Radioactive sources:** Low energy calibration; strong physics motivation
  - Requirement on position resolution and how the current design impacts physics – not clear.
- **Photon gain monitoring:** Light flashing system for commissioning the photon detector and monitoring its relative gain
  - Needs optical feedthroughs for fiber optics. The fibers are fragile and a significant number needed along the plane.
- **Laser system**
  - If we want to do this, will need 16 additional penetrations
  - DUNE has unique challenges, so need studies and well founded arguments for recommendation.

What is clear though: Making instrumentation ports accommodate multiple systems is a good strategy. <u>Needs calculations</u> on the penetration width taking into account various systems.

One proposed design for penetrations – Jim Stewart

(only showing the instrumentation ports)



- **Increase the size of penetrations to accommodate multiple systems:**
  - Change 250 mm → >275 mm (maximum allowed); 300 mm is risky
  - It is not clear what is actually needed based on width requirements from Multiple systems?

- **Adding additional 4 feedthroughs**
  - motivated for Radioactive source calibration to get better position resolution
  - The argument for adding 4 new ports Vs spreading the existing (red) 8 ports need to compared/studied (8 vs 12)

Addressing the FT width question?

- What are the FT width requirements for various systems? (take into account multiple systems will share a single FT)
- **Strategy:** Get the requirements from users from each port and draft a plan.

Charge to various people:

- Radioactive source (Jonathan, Juergen): A table listing the most desirable radioactive sources for DUNE and for each choice what is the required FT size?
- Thermometers (Jelena, Anselmo): Assuming protoDUNE design can be extrapolated, what is the FT requirement? (take into account fixed vs dynamic vertical T-gradient)
  - Fluid flow simulations required to understand number of thermometers (pursue Eric Voirin, Stephen Pordes)
- Purity Monitors (Andrew, Jianming, Mario): Can protoDUNE model be extrapolated? How many PMs? FT width requirement?

Do we need additional 4 FTs?

(charge to Jonathan, Juergen, Kate, Bob)

- What are the energy and position resolution requirements for DUNE for low energy calibration?
- Position resolution studies comparing 8 vs 12 scenario Vs spreading the 8 over the cryostat center (symmetry important). Strong arguments or studies showing either change is needed?
- Other considerations:
  - How close can one take the source to the field cage? (Jonathan, Bo)
  - Risk factors: Radioactive source can get stuck (well founded concern), what can be done to assess the risk, mock-up tests and considerations in mechanical design? (Juergen)
  - How does this impact other systems? E.g. What accommodations does DAQ have to make in their design? Pre-scale triggers, hardware triggers, special run control etc. (Juergen)
  - Other factors that can impact the design or physics and limit the performance? e.g, field variations, flow patterns etc.

Laser System

(Francesco, Michele, Igor, Vitaly & ICARUS experts)

- Currently case studies:
  - ICARUS, MicroBooNE, CAPTAIN, T2K, Reactor (?)
- Multiple scenarios:
  - 1 penetration, 100% coverage: Keep it close to APA and the laser can sweep from APA to CPA
  - Partial coverage, localized and then extrapolate
  - Ionization vs Photo-calibration system
- Advantages: Redundancy, superiority to cosmic rays
- Disadvantages: ionization along the track, high energy, range
- Calibration with cosmics vs Laser – studies needed; need to tie to high level physics requirements
- Will need additional penetrations. Risk/Cost assessment: penetrations now vs later

Moving forward

- Experts and key stake holders for each system being identified.
  - Focused meetings with experts followed by specific questions and request for additional studies/arguments
- Consortium/TF meetings starting up this/next week.
- Better understanding of physics-driven calibration requirements will be the focus.
  - Understanding calibration reach with cosmics needs quantified
  - Short term focus: defining cryostat penetrations
- For the cryostat design timescale, detailed studies not possible. But, will pursue experts to provide their best arguments and preliminary studies.
- Hopefully we will have something to say by the cryostat timeline.